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To evaluate the quality of the effluent stream from a wastewater treatment plant the number of measurements required will depend on the degree of precision required by the regulatory agency. The following list represents a minimum set of measurements to characterize the effluent with respect to its impact on the receiving stream: Volume flow (mgd), Water temperature, pH, Suspended solids concentration (mg/l), Total organic concentration (COD, TOC, TOD, TC).

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MONITORING OF THE EFFLUENT STREAM FROM WASTEWATER TREATMENT PLANTS

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December 1971

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MONITORING OF THE EFFLUENT STREAM FROM WASTEWATER TREATMENT PLANTS

To evaluate the quality of the effluent stream from a wastewater treatment plant the number of measurements required will depend on the degree of precision required by the regulatory agency. Both the volume flow and the concentration of contaminants will vary diurnally and seasonally. In some instances 24 hour composite samples will be sufficient, in other cases the diurnal variation will be measured. Ideally, all measurements should be made on-line 24 hours per day and 365 days per year. Automatic instruments to accomplish this task, however, are not available at this time. The following list represents a minimum set of measurements to characterize the effluent with respect to its impact on the receiving stream:

1. Volume Flow, mgd
2. Water Temperature
3. pH
4. Suspended Solids Concentration, mg/l
5. Total Organic Concentration; COD, TOC, TOD, TC

The stream analyst might wish to substitute a measurement of 5-day BOD or an oxygen uptake measurement as an alternative or in addition to the fifth measurement shown in the list.

The first three measurements listed above can be made continuously, but periodic maintenance will be required. An instrument which will measure suspended solids concentration with good precision does not exist at this time. Several instruments are available which operate on the principle of adsorbed or reflected light similar to

a turbidometer. Under ideal conditions, the turbidity measurement can be related to suspended solids in the range of 0-100 mg/l. One alternative is to write the effluent standards in terms of turbidity instead of suspended solids. A typical price for this kind of instrument is $1580 for the instrument and about $300 for the recorder. In the laboratory, suspended solids determination is simple and easy to perform. The turbidity type of instrument has the advantage of continuous on-line performance.

In the measurement of suspended solids, total organic carbon, and biodegradable organic carbon, the instruments available either require significant amounts of maintenance and calibration time or the measurement made is not truly equivalent to the corresponding wet chemistry method. The question, therefore, arises whether the use of the automatic instruments offers any true advantages over providing a laboratory and hiring a full time chemist to make the wet chemistry measurements. This question will be examined later in this report, after the cost of the automatic instruments and the cost of the alternative wet chemistry method are presented.

The traditional 5-day BOD is time consuming to perform in the laboratory and has the disadvantage of the 5 day delay which precludes the use of the measurement for plant control. An oxygen uptake measurement can be made with an instrument marketed by Badger Meter Manufacturing Company which will measure the oxygen depletion in the sample over a 15 minute time period. The cost of this instrument is now quoted as $3800 and the installation cost is estimated at $1000. This instrument can be used to measure the concentration of

biodegradable organics, but an operator will be needed essentially full time to service and attend the instrument.

If a measure of total organics species (TOC) is needed, instruments manufactured by Beckman Instruments, Inc. and Ionics, Inc. can be used to measure total organic carbon. The Beckman instrument is a laboratory instrument and a chemist is required to prepare the sample and to service and attend the instrument. The Ionics instrument is partially automatic and can be used on-line with or without a filter in the sample line. This instrument will also require significant attention and service to assure reliable and accurate measurements. The cost of the Beckman instrument is $6195 complete. The Ionics, Inc. total organic carbon analyzer which is an on-line instrument takes a sample every three minutes. This instrument is fed by an 1/8 inch line and will accept particles less than 1/16 inch in diameter. The total cost of the Ionics TOC analyzer is $9775.

Ionics also markets a Total Oxygen Demand instrument which is similar to the TOC instrument in that it will accept some particles. The TOD measurement represents all organic species which can be combined with oxygen. The cost of the TOD instrument is $8750. The estimated installation cost for each Ionics instrument is $1000.

The TOC and the TOD measurements are similar to the COD wet chemistry method in that they do not measure the biodegradable fraction of the organics present. Some instruments also make a measurement of carbon before the dissolved carbon dioxide is removed and this measurement is commonly called total carbon (TC.) Some

minimal savings in cost can be realized if this measurement can be substituted for the TOC measurement. The COD measurement requires laboratory space and some glassware. Up to 72 COD determinations can be made by one chemist in an 8 hour period.

Probably the most reliable way to measure the effluent volume flow is with a Parshall flume. The Parshall flume is essentially a Venturi with the water surface open to the atmosphere. The flow is a non-linear function of the pressure drop across the Venturi. The Parshall flume requires a concrete structure to support the fiber-glass Parshall flume housing. The estimated cost of the concrete structure, the connecting pipeline and the fiber-glass housing is shown in Figure 1. The cost of the electronic transmitter which also interprets the non-linear pressure differential in terms of volume flow is approximately $600. The recorder which gives instantaneous flow, as well as the daily totalized flow, costs approximately $700. If the flow recorder is positioned in the administration building, the length of electrical cable will be about 70 ft. for a 1 mgd plant, about 220 ft. for a 10 mgd plant and about 680 ft. for a 100 mgd plant. The cost of two two-conductor wires in conduit will be about $150 for a 1 mgd plant, $400 for a 10 mgd plant and about $1200 for a 100 mgd plant.

For an additional $300 the totalizer can be used to control a proportional sample of the effluent stream. This, of course, does not include the cost of the sampler. The cost of the sampler will be in the range $1000-2000.

COST OF EFFLUENT VOLUME FLOW MEASUREMENT
with
PARSHALL FLUME

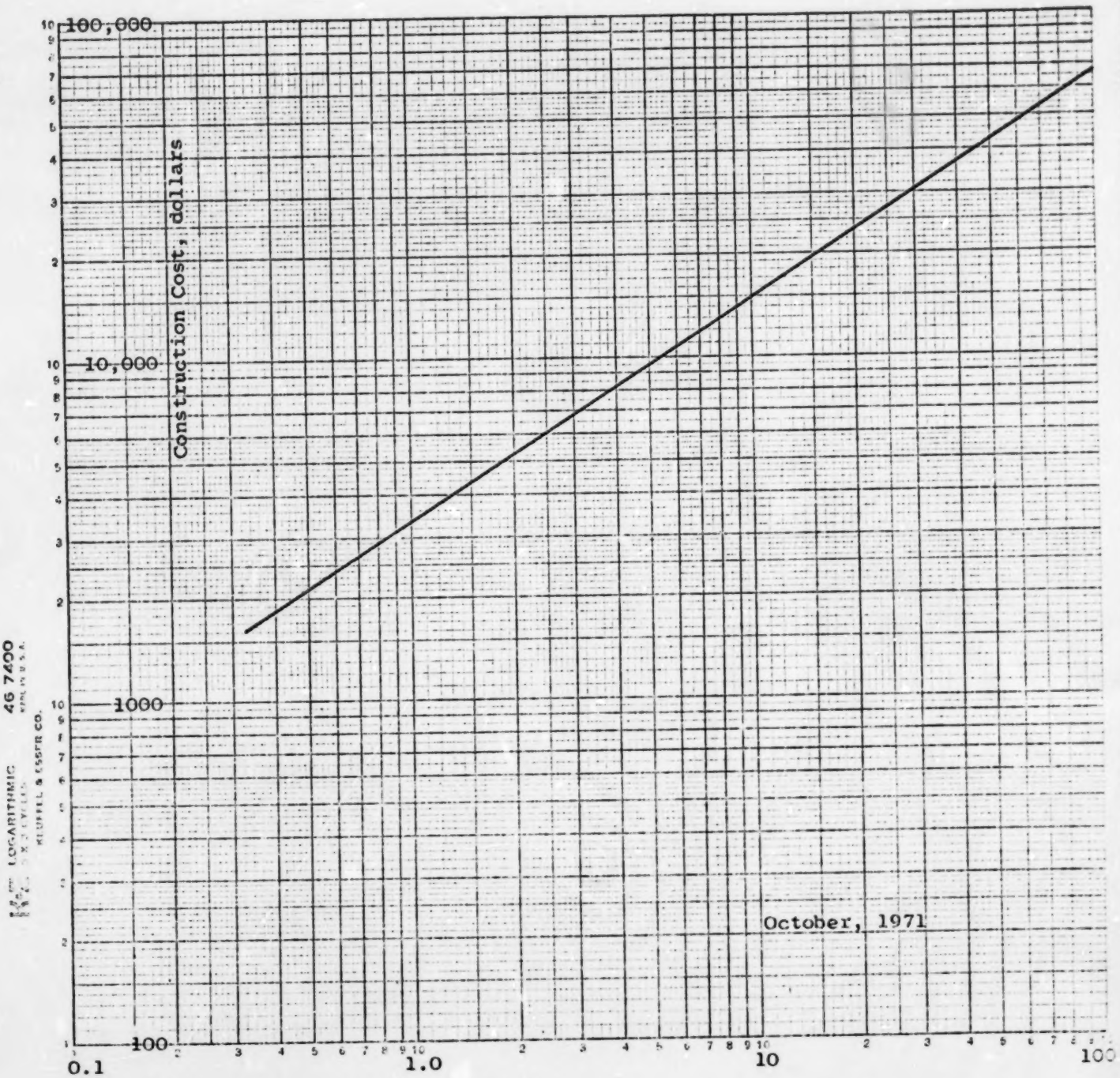

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Figure 1

For water temperature measurement, a resistance type thermometer would be the best choice. The thermometer will cost about $80. One electronic transmitter will cost about $200 with an additional $131 for installation. The recorder will cost about $300. Electrical wiring will cost about $150 for a 1 mgd plant, $400 for a 10 mgd plant and $1200 for a 100 mgd plant.

The electrode cell for pH measurement sells for about $300. The transmitter will cost about $600 with an additional $131 for installation. The recorder will cost about $300. Electrical wiring will cost about the same as the temperature probe.

An alternative to automatic instrumentation is wet chemistry which requires adequate laboratory space, analytical instruments and glassware. Laboratory facilities are normally installed in treatment plants, although in the smaller plants they are often not adequate. The mimimum recommended laboratory space is about 20 ft. by 23 ft. in floor area. A prefabricated building of this size can be constructed for about $21.25 per square foot, or a total of about $10,200. A total of about $17,100 will be required to equip such a laboratory. An itemized list of recommended equipment is shown with a floor plan of the laboratory in Figure 2. For effluent monitoring alone, one chemist should be adequate. The level of chemist should be about equivalent to GS-7 in the government service. The yearly salary would be $10,298 plus 15% for payroll extras, making a total of $11,843 per year.

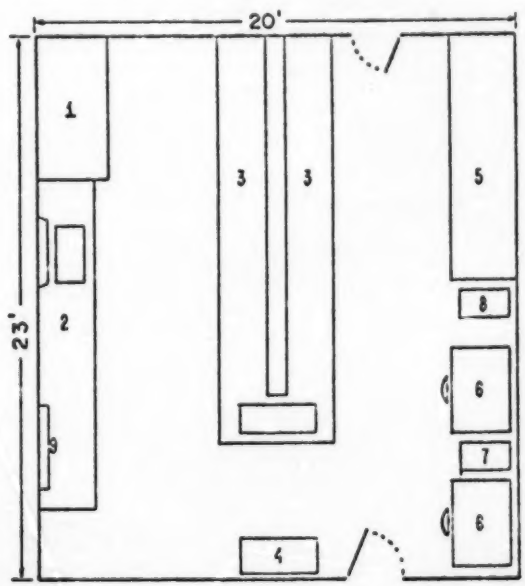
A summary of construction cost estimates for effluent monitoring is shown in Table I. A 9x12 foot building has been provided at the

EQUIPMENT FOR ANALYTICAL LABORATORY

Approximate Costs of Analytical Hardware

Bench space	$ 6,500
Desks and other furniture	500
Glassware	1,000
Analytical equipment	
Dissolved Oxygen Probe	500
Analytical Balance	1,000
Spectrophotometer	2,000
pH Meter	500
Conductivity Meter	300
Kjeldahl Digestor and Dist'n App.	1,000
Hot plates, flasks, condensers and titration equipment	450
Drying Oven	500
Muffle Furnace	600
Water Still	750
Wall cabinets, pegboard and miscellaneous	1,500
	$17,100

SAMPLE LAB.



1. FUME HOOD.
2. BENCH UNIT W/ SINK & PEG BOARD.
3. PENINSULA TYPE BENCH W/ CENTER DRAIN, SHELF & SINK.
4. CHEMICAL STORAGE.
5. INSTRUMENT TABLE W/ REGULATED VOLTAGE.
6. DESKS.
7. FILE CABINET.
8. BALANCE TABLE.
9. TITRATION TABLE.

Figure 2

TABLE I

CONSTRUCTION COST FOR EFFLUENT MONITORING FACILITIES

	Design Capacity = 1 mgd	Design Capacity = 10 mgd	Design Capacity = 100 mgd	
Flow Measurement (Parshall flume)	$ 4850	$16700	$68500	
Water Temperature Measurement	861	1111	1911	
pH Measurement	1350	1600	2400	
Subtotal No. 1	$7061	$19411	$72811	
Turbidity - Suspended Solids	1880	1880	1880	
Total Organic Carbon	10775	10775	10775	
Oxygen Uptake	4800	4800	4800	
9 ft. x 12 ft. Building at sampling point	4000	4000	4000	
Subtotal No. 2	$21455	$21455	$21455	
20 ft. x 24 ft. Analytical Chemistry Building	10200	10200	10200	
Laboratory Equipment	17100	17100	17100	
Subtotal No. 3	$27300	$27300	$27300	

sampling point to house the automatic sampling equipment to minimize the length of the sampling lines. Notice that subtotals 2 and 3 are not significantly different. If we also consider the fact that most wastewater treatment plants are normally equipped with laboratory facilities, the cost advantage appears to be in favor of using wet chemistry for suspended solids, COD and oxygen uptake or BOD. It is estimated that one full time chemist will be needed to service, operate and calibrate the automatic instruments and that one full time chemist can also make sufficient measurements by the wet chemistry method.

Although the best strategy will depend on the number and kind of measurements required, it would appear reasonable to measure flow, water temperature and pH automatically and rely on the wet chemistry laboratory to perform the COD, BOD, and suspended solids measurements. The construction cost involved would be the sum of subtotals 1 and 3. This amounts to $ 34,361 for the 1 mgd plant, $46,711 for the 10 mgd plant and $100,111 for the 100 mgd plant. Since the major part of the cost is in the Parshall flume, we can amortize this cost over 25 years at 6%. In terms of cents/Kgal the cost would be 0.7 cents/Kgal for 1 mgd, 0.1 cents/Kgal for 10 mgd and 0.02 cents/Kgal for 100 mgd. The cost of one full time chemist would be 3.2 cents/Kgal for the 1 mgd plant, 0.32 cents/Kgal for the 10 mgd plant and 0.032 cents/Kgal for the 100 mgd plant. The total cost would be the sum of amortization and one full time chemist. This amounts to 3.9 cents/Kgal for 1 mgd, 0.42 cents/Kgal for 10 mgd and 0.05 cents/Kgal for 100 mgd